



High-Temperature Effects on Rainfall-Runoff Processes

Products	Infiltration module in the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) to incorporate temperature effects. The new capability has been available in HEC-HMS since Version 3.1 was released in November 2006.
Benefits	The study will provide fundamental knowledge of the effect of temperature on rainfall-runoff processes, which can be adopted by physically-based rainfall-runoff models to enhance model accuracy. The new module in HEC-HMS will give flood-control managers a means to account for variations in flood potential in arid and semi-arid environments.
Issue	<p>The impact of temperature on surface runoff is a consequential result of the temperature impact on infiltration. The temperature impact on infiltration is both positive and negative (Grant 2003), depending on the soil texture. Temperature changes simultaneously affect two major parameters involved in the infiltration process: the soil hydraulic conductivity and the capillary potential. Increasing temperature decreases water viscosity, which leads to increasing infiltration; however, increasing temperature decreases capillary pressure, which reduces the gradient and hence, reduces the infiltration rate. Consequently, the temperature impact on runoff is dualistic. The overall impact can be important when predicting surface runoff generation in arid and semi-arid areas because of large temperature variations during the year. The overall impact has never been studied.</p>
Description	To quantify the temperature effect on surface runoff, an infiltration model combined with a surface runoff model is employed to simulate the rainfall-runoff process. The temperature effect for the infiltration process is corrected based on the study of Grant (2003). Two types of modeling were conducted: (1) the normalized model to elucidate the general impact of temperature on runoff generation; (2) dimensionalized model to examine temperature impacts under practical conditions. Different soil types were employed using the USDA classification with typical soil parameters. The results showed that hydraulic conductivity was most affected by changes in temperature, where increased temperature increased the hydraulic conductivity and reduces runoff volume. However, this effect is also influenced by boundary conditions (i.e., hydraulic gradient). If equivalent boundary conditions (normalized cases) are set for every soil texture, the temperature effect is similar for all soils with slightly larger impact on coarser-textured soils. If the same practical boundary conditions are examined for the dimensionalized cases, the temperature



effect cannot be generalized for all soils. Results indicate a more significant temperature effect on soils with higher conductivity values (e.g., sandy soils). Rainfall rate and duration does influence the temperature effect. Higher rainfall intensity and longer rainfall duration tend to reduce the temperature effect. The mathematical model developed during the research phase was incorporated into HEC-HMS as a new loss rate (infiltration) method. The new method uses the Smith-Parlange model of the infiltration process and incorporates the temperature effects found previously. A temperature time-series is specified by the user to describe the environmental conditions. Changes in water density, viscosity, conductivity, and hydraulic gradient are then determined and incorporated into the infiltration calculations. The new capability has been available in HEC-HMS since Version 3.1 was released in November 2006.

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Points of Contact William Scharffenberg, USACE Hydrologic Engineering Center
Email: William.A.Scharffenberg@usace.army.mil
Phone: 530-756-1104

Li Chen, Division of Hydrologic Sciences, Desert Research Institute
Email: Li.Chen@dri.edu
Phone: 702-862-5349

Michael Young, Division of Hydrologic Sciences, Desert Research Institute
Email: Michael.Young@dri.edu
Phone: 702-862-5489

Lisa Hubbard, Program Manager, ERDC, Coastal and Hydraulics Laboratory
Email: Lisa.C.Hubbard@usace.army.mil
Phone: 601-634-4150

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